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(54) Continuous Casting Chill Mould and Associated Cooling System

(57) The mould comprises a block (8) of graphite containing a moulding cavity. A number of external cooling pipes (11) are individually urged resiliently against external surfaces of the block and are able to move individually with respect to the block e.g. by virtue of the block (8) having flat outer surfaces (24', 24'') on which the pipes (11) rest. The pipes (11) can be of rectangular cross-section, each being attached to the rest of the system through resilient compensators (9). Pressure of coolant flowing thereby urges the pipes (11) against the block (8).

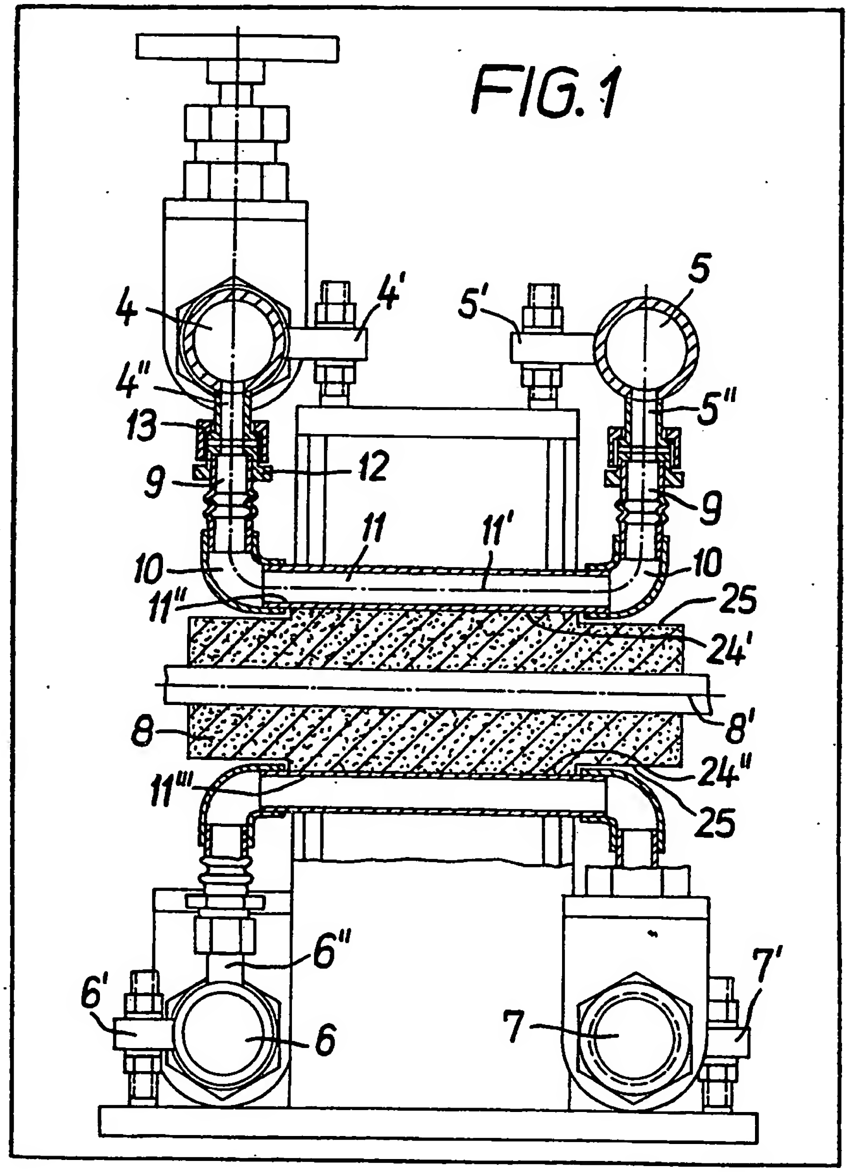

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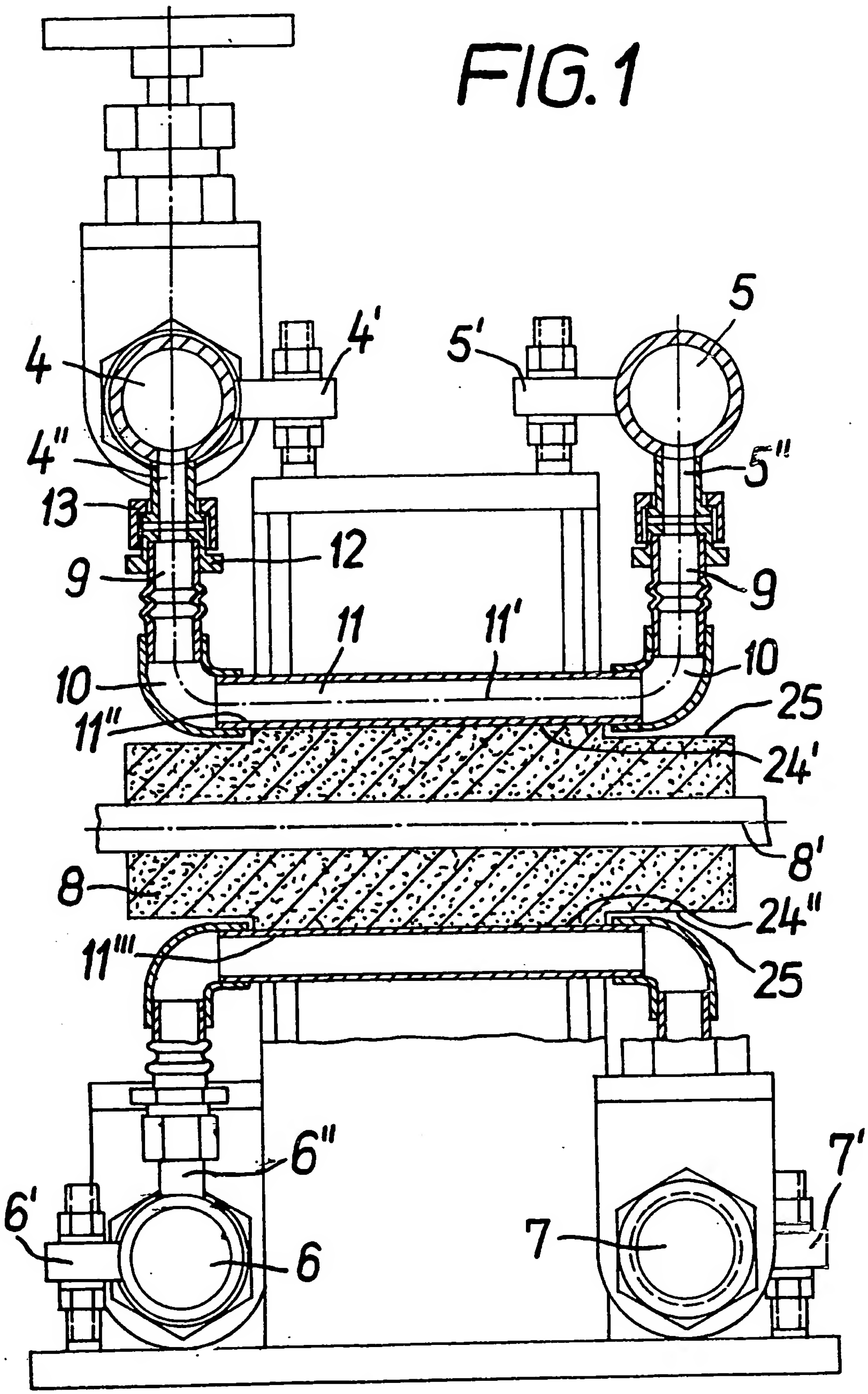
FIG. 1



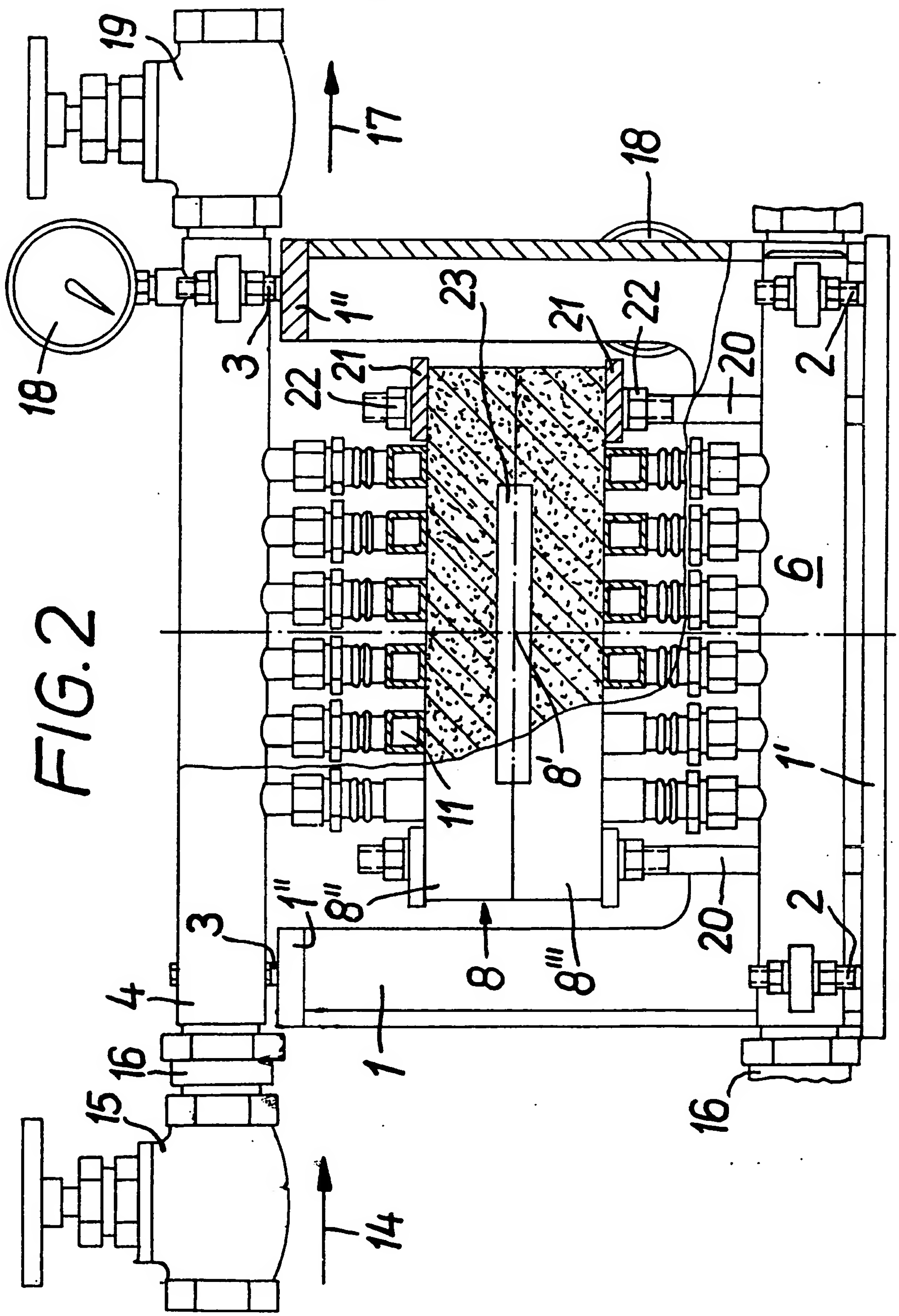


FIG.2

SPECIFICATION

Continuous Chill Mould

The invention relates to a continuous chill mould, especially with rectangular mould cavity, for the continuous casting of metals, especially copper and copper alloys, consisting of a graphite block of one or more parts and a cooling system of one or more parts which is in force-effected connection with the graphite block.

In the continuous casting of copper and copper alloys, especially with a horizontal casting procedure, the use of graphite as mould material has proved its value by reason of the good lubricating property of graphite with adequate thermal conductivity.

From German Publication Specification No. 1,217,556 an all-graphite chill mould is known into the cooling bores of which cooling pipes are fitted with over-size. The cooling pipes abutting under spring stress on the bore wall are provided with longitudinal expansion ribs which are intended to prevent an excessive pressure from being exerted upon the graphite—by reason of the different expansions of copper and graphite at high working temperatures. In contrast to other graphite moulds—where the graphite sleeve is enclosed by a water-cooled copper jacket and in which, especially in the case of rectangular mould cavities, there is danger that the graphite insert may detach itself from the copper jacket—the known construction type possesses the advantage that secure abutment of the cooling pipes on the mould material is always guaranteed; however its disadvantage consists in that it is extraordinarily delicate and costly. Especially the working of the graphite block and also the machining in of the cooling bores involve high expense and there is danger that the graphite may be damaged in the fitting of the cooling pipes into the cooling bores. Since removal of the cooling pipes inserted into the cooling bores is economically hardly acceptable, but the graphite is subject to relatively high wear, the use of the known chill mould involves high costs. Therefore it appears at most possible to use the known chill mould for the production of lengths of large format with a vertical casting procedure.

The invention is based upon the problem of producing a continuous casting mould which, like the known chill mould, constantly guarantees satisfactory cooling of the graphite block, but the use of which on the other hand necessitates substantially less expense than the use of the known chill mould. More especially the newly proposed continuous casting chill mould should be formed in such manner that the chill mould costs which enter into the working costs of the continuous casting plant can be kept relatively low.

In a continuous chill mould of the initially stated classification the set problem is solved in that this mould possesses the features of Claim 1. The idea of the solution on which the invention is based thus consists essentially in holding each cooling pipe individually and freely movably in abutment on the outer surface of the graphite block. The expression "freely movably" is here intended to express that each cooling pipe is connected with the associated cooling system in such manner that it can move in any desired direction, that is especially horizontally and vertically, and can follow every shift of the graphite block, without losing contact with the latter. The connection of the cooling pipes with the associated cooling system or systems is formed especially also in such manner that the cooling pipes can carry out movements in relation to the outer surface of the graphite block, but are always held in abutment on the block.

Each cooling pipe expediently lies flat on the outer surface of the graphite block (Claim 2), the outer surface of which block—which especially may also be composed of several individual surfaces (Claim 4)—is preferably smooth (Claim 3).

The expression "smooth" is here intended to indicate that the outer surface, or possibly the individual surfaces, of the graphite block can be made continuous, that is to say have no recesses, depressions, grooves or the like of any kind.

If the graphite block is made of rectangular form, that is rectangular or square, it thus has four smooth individual surfaces against which the cooling pipes rest flat. The cooling pipes preferably have, at least on the side facing the graphite block, a surface which is adapted to that of the graphite block; thus they especially comprise at least a rectangular or semi-circular external cross-section (Claims 5 and 6).

Further preferred forms of embodiment of the object of the invention additionally possess at least the features of one or more of Claims 7 to 11.

The use of a thermally conductive paste, especially a paste on a basis of silicone, has the advantage that even in the case of lower demands of the surface quality of the contact surfaces under consideration, that is the abutment surface of the cooling pipes and the outer surface of tha graphite block, an adequate heat transmission is achieved.

The invention is to be explained in greater detail hereinafter with reference to an example of embodiment illustrated in the accompanying drawings, wherein:—

Figure 1 shows a vertical longitudinal section through the novel continuous chill mould and

Figure 2 shows a vertical section transverse to the longitudinal axis of the continuous chill mould.

In the drawings, the novel continuous chill mould comprises as supporting element a carrier frame 1 having a bottom plate 1′ and upper carrier plates 1″, to which threaded bolts 2 and 3 are secured. An upper feed pipe 4 and an upper discharge pipe 5 are screwed to the upper threaded bolts 3 with interposition of welded-on plates 4′ and 5′; a feed pipe 6 and a discharge pipe 7 are secured in corresponding manner to the lower threaded bolts 2, with interposition of

welded-on plates 6′ and 7′ respectively.

Pipe connectors 4″, 5″ etc., adjoined by U-shaped pipe systems (the pipe connectors associated with the lower discharge pipes 7 are not illustrated) are welded to the feed and discharge pipes in the direction towards the graphite block 8—preferably at regular intervals. These pipe systems consist each of two metal compensators 9, two pipe elbows 10 and a straight cooling pipe 11 with rectangular external and internal cross-sections, the longitudinal axis 11′ of which extends parallel with the longitudinal axis 8′ of the graphite block 8.

The metal compensators 9 are connected, adjustably by means of a threaded bush 12 secured to them and a cap nut 13, with the associated pipe connector 4″, 5″, etc. in each case. The feed pipe 4 is provided in the feed direction of the cooling water (arrow 14) with a quantity-regulating valve 15 with water quantity-measurement 16; a manometer 18 and a regulating valve 19 are installed in the discharge conduit 5 in the discharge direction (arrow 17). The lower feed pipe 6 and the lower discharge pipe 7 are equipped with corresponding fittings which are not illustrated, for the sake of clarity.

The graphite block 8, which has a rectangular external cross-section and consists of an upper part 8″ and a lower part 8‴, is held through threaded bolts 20 in the rigid carrier frame 1. The parts 8″ and 8‴ are braced against one another by means of clamping nuts 22, with interposition of clamping plates 21, and enclose a rectangular mould cavity 23.

The upper and lower parts of the graphite block 8 are provided on the outwardly facing side in each case with a smooth individual surface 24′ and 24″ respectively which extend parallel with one another and parallel with the longitudinal axis 8′. The straight cooling pipes are held in abutment on the individual surfaces 24′ and 24″ under slight initial stress—which is generated by the metal compensators 9—outside the region of the pipe elbows 10, in each case by means of their smooth outer surfaces 11″ and 11‴ which face the graphite block 8.

If as may be seen from Figure 1 the cooling pipes 11 are shorter than the longitudinal dimension of the graphite block 8, the latter is provided with steps 25 in the region of the pipe elbows 11, that is to say in the region of its forward and rear end sections; these steps are expediently dimensioned so that the mobility of the cooling pipes 11 and of the associated pipe elbows 10 in relation to the graphite block is not hindered.

The effective length of the cooling pipes 11 preferably conforms with the length of the graphite block 8, so that the pipe elbows 10 lie outside the graphite block and the latter has continuous smooth individual surfaces 24′ and 24″.

After the regulating valves 19 are opened the cooling liquid pressure prevailing in the cooling circuit can be read from the associated manometers 18. Since the metal compensators 9 expand in the direction of their longitudinal axes under the action of the hydrostatic pressure, the cooling pipes 11 are held elastically by means of their abutment surfaces 11″ and 11‴ in abutment on the individual surfaces 24′ and 24″. During operation of the continuous chill mould thus there is always intimate contact between the graphite block 8 and the cooling pipes 11; a separation between the cooling pipes and the graphite block by reason of different thermal expansions of the components in contact with one another cannot occur by reason of the free mobility of the cooling pipes in every direction, that is to say especially in relation to the individual surfaces 24′ and 24″, realised by means of the metal compensators.

In order to ensure an adequate heat transmission between the cooling pipes 11 and the graphite block 8 even when the surfaces 11″, 11‴ and 24′, 24″ in contact with one another do not possess adequate surface quality, a thermally conductive paste on a basis of silicone is applied preferably at least to one of each of these pairs of contacting surfaces. The thermally conductive paste can also be applied to improve the heat transmission between the graphite block 8 and the cooling pipes 11 even if the respective contacting surfaces possess an adequate surface quality.

Since the cooling liquid pressure can be finely regulated within wide limits with a throughflow quantity predetermined by means of the quantity-regulating valves 15, a correspondingly fine adjustment of the pressure application force exerted by the cooling pipes 11 is also possible; therefore undesired deformation of the graphite block 8 can be avoided even if this block has a very great width. The newly proposed continuous chill mould is therefore especially suitable for the casting of wide lengths.

The form of embodiment as illustrated in the drawing can be advantageously supplemented in that the graphite block 8 is provided with cooling pipes on the narrow sides as well, which are connected in the above-described manner to feed and discharge pipes. Such a formation of the continuous chill mould comes into application especially of hot-rollable plates with a thickness between 80 and 250 mm. are to be cast.

In place of the metal compensators as already described it is possible also to use other compensation devices provided that these permit a free adjustment of the cooling pipes 11 in every direction to an adequate extent. The invention is here based upon the knowledge that a graphite block can be adequately cooled even if the cooling pipes are held flat in abutment on it from the exterior. This arrangement has the great advantage that the graphite block can be assembled as a simple and thus cheaply produced geometrical body and the replacement of the graphite block proceeds without difficulty.

To increase the cooling preformance and thus the casting output of the continuous chill mould,

the above-described indirectly cooled chill mould can additionally be provided with a direct cooling system in the region of the end section of the graphite block.

Claims

1. A chill mould, especially with rectangular mould cavity, for the continuous casting of metals, especially copper and copper alloys, consisting of a graphite block in one or more parts and a multi-part cooling system, the cooling pipes of which are in force-engaging connection with the graphite block, characterised in that each component cooling system comprises at least one cooling pipe (11) and each cooling pipe rests individually and freely movably on the outer surface (24′, 24″) of the graphite block (8).

2. A continuous chill mould according to Claim 1, characterised in that each cooling pipe (11) rests flatly on the outer surface (24′, 24″) of the graphite block (8).

3. A continuous chill mould according to Claims 1 and 2, characterised in that the outer surface (24′, 24″) of the graphite block (8) is smooth.

4. A continuous chill mould according to Claims 1 and 2, characterised in that the outer surface of the graphite block (8) is composed of several smooth individual surfaces (24′, 24″).

5. A continuous chill mould according to Claims 1 to 4, characterised in that each cooling pipe (11) has a rectangular external cross-section.

6. A continuous chill mould according to Claims 1 to 4, characterised in that each cooling pipe (11) has a semi-circular external cross-section.

7. A continuous chill mould according to Claims 1 to 6, characterised in that each cooling pipe (11) is held in abutment on the graphite block (8) by means of a mechanically acting initial stressing device.

8. A continuous chill mould according to Claims 1 to 7, characterised in that each cooling pipe (11) is held in abutment on the graphite block (8) by means of the force which acts upon it as a result of the regulable static cooling liquid pressure.

9. A continuous chill mould according to Claims 1 to 8, characterised in that each cooling pipe (11) is attached to the part of the cooling circuit (4 to 7) which is stationary in relation to the graphite block (8), with interposition of compensators (9) connected with its feed and discharge sections.

10. A continuous chill mould according to Claims 1 to 9, characterised in that each part of the cooling circuit which is in communication with the cooling pipes (11) allocated to a specific side of the graphite block (8) comprises its own throughflow quantity and pressure regulating devices (15 and 19).

11. A continuous chill mould according to Claims 1 to 10, characterised in that a layer of thermally conductive paste is applied to at least one of the mutually contacting surfaces—the abutment surface (11″ or 11‴) of each cooling pipe (11) or the outer surface (24′ or 24″) of the graphite block (8).

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